International Journal of Civil Engineering and Technology (IJCIET)
Volume 8, Issue 2, February 2017, pp. 89–99 Article ID: IJCIET_08_02_009
Available online at http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=2
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

© **IAEME** Publication **Scopus** Indexed

TIME IMPACT STUDY OF REAL ESTATE SECTOR CONSTRUCTION PROJECTS POST APPLICATION OF LEAN PRINCIPLES FOR DELAY RESOLUTIONS

Mohd Asim
Student M.Tech (Construction Technology & Management),
Department of Civil Engineering, Integral University Lucknow, Uttar Pradesh, India

Shumank Deep
A.M.ASCE, Assistant Professor, Department of Civil Engineering,
Integral University, Lucknow, Uttar Pradesh, India

Dr. Syed Aqeel Ahmad
Associate Professor, Department of Civil Engineering,
Integral University, Lucknow, Uttar Pradesh, India

ABSTRACT

One of the long standing issues in the field of real estate sector construction disputes claims is the determination of a party responsible for occurrence of delays, delayed duration and its impact on as-planned construction schedule. A classification of delay analysis models shows that no model yet exists that is able to collect the causes of construction delays with determination of party responsible for it by evaluating time overrun due to addition of various delays in as-planned construction schedule, and to suggest delay prevention measures to minimise their arrival in real estate projects. The purpose of this document is to develop and test of such a design method to find construction delays liability in real estate sector construction projects by collecting delays arrival causes with the prevention measures that should be adopted to minimize occurrence of construction delays. A methodology is developed for resolving real estate construction disputes claims by finding a party responsible for delay arrival and enable one to follow lean construction principles to avoid same type of delay in other work packages and in other real estate construction projects. The tests of this design method with the participants reveal that by completing the steps in the proposed design procedure, users will have detail of causes of time overrun of an activity/work package of real estate construction projects, the responsible delay caused party will be asked for compensation based on delayed time and the last step of design method provides suitable principles to users to be efficient in performing delay- free work.

Key words: Construction delays; Causes; Time impact; Lean principles; Toyota way model

Cite this Article: Mohd Asim, Shumank Deep and Dr. Syed Aqeel Ahmad, Time Impact Study of Real Estate Sector Construction Projects Post Application of Lean Principles for Delay Resolutions. *International Journal of Civil Engineering and Technology*, 8(2), 2017, pp. 89–99.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=2

1. INTRODUCTION

In Northern India, real estate construction projects could not be saved from the problem of time overrun, which signifies delays in construction projects. Due to the inherent risks and increasing complexity of modern construction projects, delays and cost overruns have become common constraints in the industry. Mathematically, construction delays are the function of time. Delay could be defined as the time overrun either beyond the contract date or beyond the date that the parties agreed upon for delivery of a project (Assaf and Al-Hejji, 2006). Delays can lead to many stereotypes i.e. disputes between owners and contractors leading to arbitration, increased costs, loss of productivity and revenue, and contract termination. In India, a study conducted by the Infrastructure and Project Monitoring Division of the Ministry of Statistics and Program Implementation in 2004 reported that out of 646 central sector projects costing about $50 trillion, approximately 40% are behind schedule, with delays ranging from 1 to 252 months (Iyer and Jha, 2006). Analysis of delays in construction projects is cumbersome and complicated because of the large number of individual activities that have to be dealt with, even for a relatively simple project. Researchers and practitioners have used many techniques to assess project delays and apportion delay responsibility among the parties involved. There are various methods that exist for schedule delay analysis. No one method is currently acceptable for all projects participants or suitable for all situations. According to Ahsan and Guha, 2010, Indian construction projects were worst on account of project completion and delivery as compared to that in China, Hong Kong, Thailand, and Bangladesh, the average schedule over-run is near about 55% in Indian scenario.

2. AN INTRODUCTION TO DELAY ANALYSIS STANDARDS METHOD

Delay analysis is the procedure of comparing as-planned and other adjusted schedules by evaluating the magnitude, impact and significance of the variation between the baseline and operating schedules along with quantifying the effect of delays impacts on a project schedule. The time impact analysis procedure was recommended for use. Time impact analysis is the process of quantifying and apportioning the effect of delay or change on a project schedule. The time impact method of delay analysis, also referred to as TIA, is a technique similar to the impacted as-planned analysis, which forecasts or predicts a delay's effect on a project's completion date and involves the insertion or addition of activities indicating delays or changes into an updated schedule representing progress up to the point when a delay event occurred to determine the impact of those delay activities.

2.1. Delay Cause Approach

The "cause" approach looks at discretely identifiable delay causes based on the contemporaneous project records. The delay-cause approach is based on the identification of delay as independent of the planned duration for an activity, and is driven by the nature of the event. This approach aligns the delay causes based on the available documentation, to understand the causes of delay.

2.2. Time Impact Analysis Definitions and Uses

Time Impact Analysis (TIA) is a scheduling technique used to quantify the effects of an unplanned event, quantify the effects of increases the work scope, evaluate potential impacts to the schedule for acceleration or delay (A TIA is forward-looking).

The TIA is identified in numerous industry publications concerning the subject of delay analysis methodologies and is the best methodology for determining the extent of impact from a potential delay event. The schedule must have a valid critical path and it is applied to the most recently updated and accepted critical path method (CPM) schedule. When done in a prospective, or forward looking, manner, a TIA can promote negotiation and ultimate settlement of any ramifications of a delay event.

From CPM in Construction Management, 6th edition book by James O'Brien and FredPlotnick,

Time impact evaluation- Use of a fragnet or sub network to evaluate the impact of an event such as a change of order or unusual occurrence on the baseline schedule; known as TIE. This is also known as time impact analysis.

AACE International recommended practice no. 52R-06,

The TIA is a 'forward looking, 'prospective schedule analysis technique that adds a modelled delay to an accepted contract schedule to determine the possible impact of that delay to project completion.

The TIA is determined by adding impacts to schedules which are statused at the end of specific windows or impact periods, typically the monthly schedule updates prepared during the project. If the entire period of the project is considered as one as-planned schedule, the TIA can also be performed in windows or periods of time, where the statused schedule and its then current critical path can be analyzed separately for each window or period, and cumulatively for the project. The goal of the systematic time impact analysis approach is to give full consideration to the actual effect of events individually and acting together, and to evaluate the effect of ongoing delays. The goal of the method is to examine the evolution of the critical path and the impact of delaying events on that path (Bramble et al. 1990). The time impact analysis approach is often the most time-consuming delay analysis method; however, it can be very accurate, has the potential to be the least controversial and most analytical, and can be equitable to all parties (Stumpf 2000).

2.3. Lean Implementation in Lucknow (U.P, India)

In recent years, the state-owned and private companies have gradually started to accept the lean approach. So far, most companies have only focused on the application of lean tools and very few have fully started the whole lean enterprise transformation. Lucknow firms held three different attitudes towards lean principles. Firstly, many companies claimed that they are lean companies because they have already implemented 5-S activities, or etc., but they have failed to appreciate the interrelationships between many other tools. Secondly, many companies believed that occurrence of delays are due to an act of God and lean principles will not stop delay occurrence. Lastly, some companies thought that they completed their lean transformation years ago. Figure 2 highlights the forces behind the potential for implementing lean principles in the Lucknow (U.P, India).

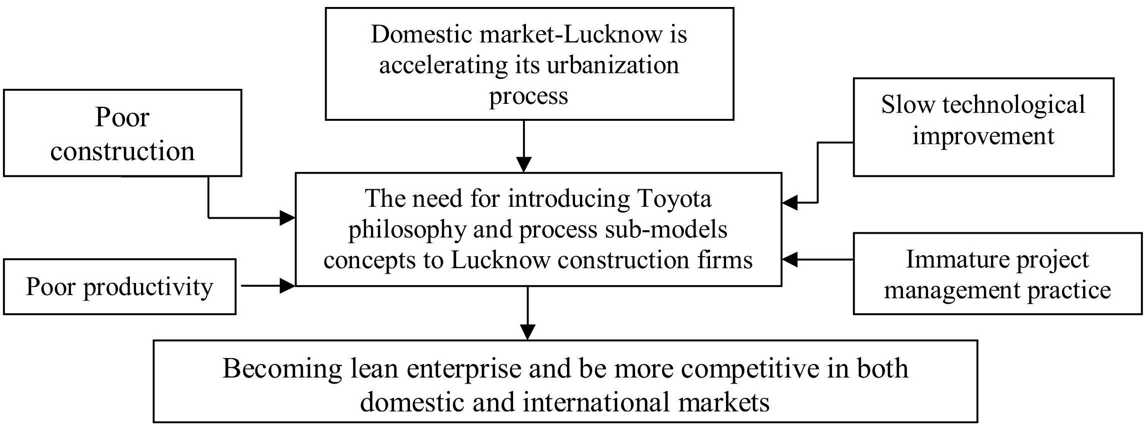

Figure 1 Driving forces behind the need for introducing lean principles in Lucknow construction firms

2.4. Toyota Way Philosophy Sub Model to Prevent Occurrence of Construction Delays at Management Level

As stated by Liker (2004), Based your management decision on the long-term philosophy, even at the expense of short-term financial goals" has been outlined as the first principle of the Toyota Way (Liker 2004).The following principle is the most philosophical foundation since it does not define hard action items but focuses a number of guiding principles of the company that Toyota firmly believed and stuck to it. The philosophy model explains the following parameters which when implemented can reduce the chances of time overrun in real estate sector construction projects.

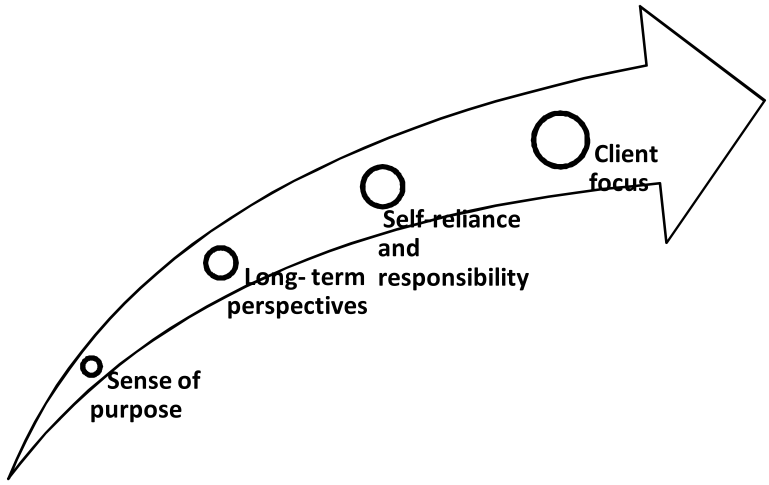

Figure 2 Toyota way philosophy model

Sometimes either contractor or third party causes delays in construction projects to make more profit. But it must not the driving purpose of contractor or owner. They must adopt strategy of "constancy of purpose" for growth in sales of deliverables and hence profit (sense of purpose).To avoid delays during construction work/designing phase construction organization must not dismiss its employees because of a temporary downturn and it must sustain a long-term relationship with the suppliers (long term perspectives).Construction industry must have unique spirit of "let's do it ourselves" and self reliance. Self reliance helps in developing core-competitiveness. At firm, the champion to self-reliance is responsibility for its own successes and failures (selfreliance and responsibility). The management endeavours to ensure that all tram members and departments realize their dual roles, namely that they are not only the customers of the previous operation but also the suppliers to the next operation downstream.

2.5. Implementation of Toyota way Process Model in Construction

In this section, efforts are made to put the seven core Toyota way principles under the "Process" category in the real estate construction industry. Picchi and Granja (2004) observed, in most cases the building professionals only put one lean construction tool into practice and missed the need to interact with other lean tools.

2.5.1. One piece flow to bring problems to the surface

It allows construction activities move continuously through the processing steps with minimal waiting time in between them with the shortest duration requirement and it will produce high efficiency in construction phase. In construction, creating a continuous process flow on-site is a huge challenge due to its fragmented nature, low standardization pattern of activities and so on. This process suggests three operationalized measurable in real estate construction agency that can regulate continuous flow of work without delay namely, waste elimination, labor flow and material flow and aims to eliminate

the physical buffers (materials or time) between production processes. To achieve that, cutting out wasted effort and time that is not adding value (waste) is mandatory. The construction work done can be represented by production line and it must follow and run parallel with the Takt time (german word for rhythm or meter). Takt time in a real estate construction project can be defined as the rate at which a builder must build a house to satisfy customer demand and calculated by dividing the effective operating time of a construction process by the quantity of items customers require from the construction process in a certain time period.Production line if goes faster, it will overproduce and causes mistakes or errors which produce an environment of delay for repairs or reconstruction and if it goes slower, it will create bottlenecks and increases overall cost of projects. The takt can be used to set the pace of construction and advise the workers whenever they are getting ahead or behind schedule.

In order to avoid delays due to lack of communication, inadequate manual operation, loading and unloading parts from equipments construction resources like equipments, labours, machines must be arranged around the edge of a u-shape, allowing workers to walk the shortest distance from process to process and performing other manual operations .It will assist communication and allows the workers access to a number of machines and to be able to operate several machines.

2.5.2. Use Pull kanban System to avoid Overproduction

In construction, pull is ultimately driven by target completion dates, but specifically applies to the internal customer of each process. A push system releases a job (eg, materials or information) into a construction production process (eg, factory line, or workstation) precisely based on pre-assigned due dates. Hence, a push system minimizes delay due to materials shortage and unavailability of sufficient information. In contrast, a pull system releases a job into a system based on the state of the system (the amount of work in process and quality available) in addition to due dates. This avoids excess inventory resulting from bad guesswork. This technique is very useful to avoid delays in modular construction techniques and prefabrication. The kanban system enables construction teams to get materials from the market place on daily basis, according to the site needs. One of the first priorities of the pull production system is to achieve reliability of processes and synchronized flows involving a stable product mix.

2.5.3. Level out the Workload (Heijunka)

The overburden of work on labours, staff and on equipments reduce their efficiency and further rate of performing work slows down due to sickness. In this case situation of staff getting sick is common and so it will act as barrier to construction process. The operationalized measurable includes the level of material inventory.

- Eliminate overburden to staff, labours and equipments (muri).
- Eliminate unevenness in the production schedule (mura).
- Level out the workload of all construction and service process.
- Weekly plan can be prepared accordingly.

2.5.4. Build a culture of stopping to fix Problems

It can be interpreted as “do it right the first time” which is the overarching goal of total quality management. However, quality culture in the construction industry prefers to use the inspection period to fix occurring problems rather than to apply the Toyota way’s built-in –quality approach to eliminate the defects in the first place.

- Deliver perfect first time quality
- Reveal and solve problems at the source as they occur
- Keep quality control simple (quality circles)

- Create culture, involve and empower employees to continuously improve

2.5.5. Standardized tasks are the foundation for keeping project work as per defined schedule

It implies that all work should be highly specified in terms of timing, content, sequence and outcome. Creating standardized work requires identifying the repeatable elements of a process, assessing the best way to perform those elements, developing a reliable method to ensure the performance of those elements and then performing the reliable method according to a required time.

- Standardized operating procedure-level of off-site technique usage
- Continuously improve level of standardized work
- Empowered employees to participate in writing of standard procure

2.5.6. Use visual Control so no problems are hidden

Visual management in construction is needed due to a number of factors such as physical environment involved, construction technology and contractual relations that result in difficulties visualizing the flow of work in progress on-site. Basically, visual management practices can be classified into different layers of visual workplace framework namely visual order, visual standards, visual measures and controls and visual guarantees. Visual control system has 5 aspects

- Written communication are easily accessible
- Visibility, communication with pictures and signs
- Consistency, each activity adopts the same conventions
- Detection, alarms and warnings will work when abnormalities occur
- Fail-saving, these activities prevent abnormalities and mistake

The concept of 5 S's is presented to perform work without any delay. This process leads to fewer construction hazards and hence help in minimize delays due to accidents/injury and less clutter that might interfere with productive work.

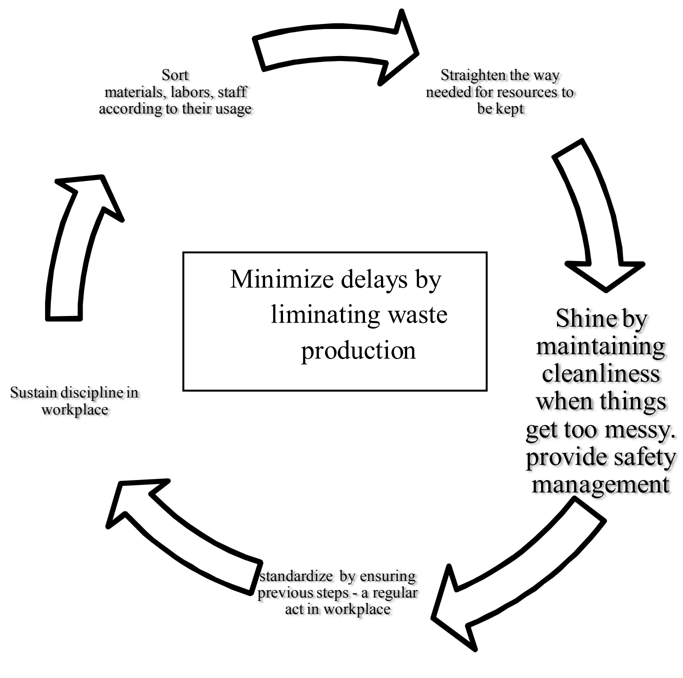

Figure 3 The five S'S

2.5.7. Use of Reliable and Proven Technology to serve People and Process

Real estate sector organization, which is still very labour intensive, aims to be on the cutting edge of technology. Thoroughly test new technology, technology must support people and company values and technology must improve people. Building professionals have attempted various new technologies, in the hope of improving performance, in an industry which is known for its slow rate of adopting new technology.

3. DESIGN/METHODOLOGY/APPROACH

To perform the steps in proposed design method, delay cause approach is inserted to summarize reasons for delayed work in a critical path of project. Time impact method is used for comparing as-planned construction schedule with delay loaded construction schedule by identifying project delays or changes, and then inserting or adding activities which represent the delays or changes into an updated schedule representing job progress just prior to the occurrence of a delay or change. The resulting schedule demonstrates the effect of the delays or changes on the project completion date. The last step suggests an implementation of the Toyota Way Model principles to minimize the occurrence of construction delays and to solve delay related problems in real estate construction projects.

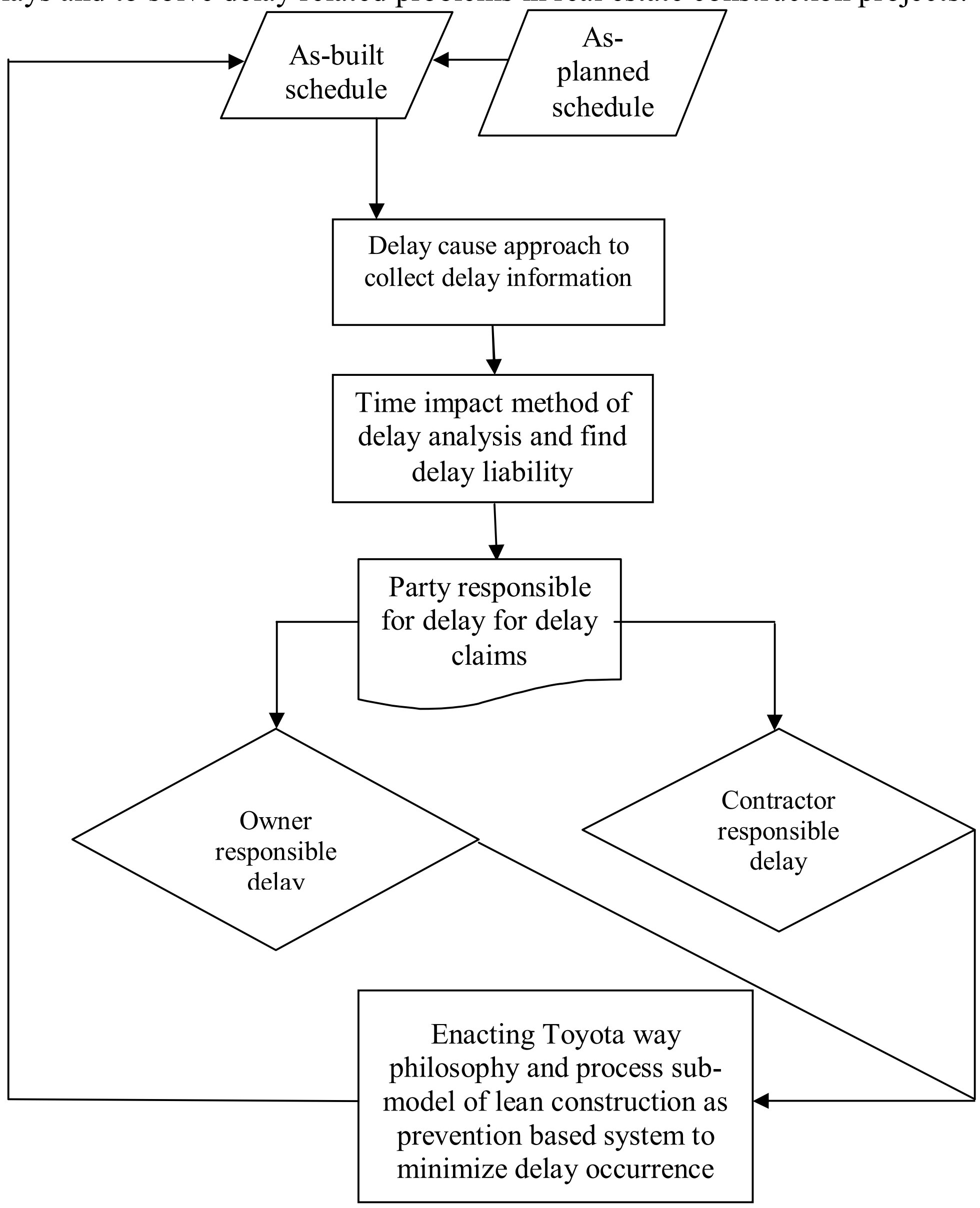

Figure 4 Flowchart representing methodology

4. CASE STUDY

The example, which will be used, is comprised of four activities and three delays that occur on the short project. The four activities are (1) the excavation of soil, (2) owner approval of .road drainage structure drawings, (3) installation of a new road drainage structure, and finishing with (4) soil backfill. The as-planned schedule and as-built schedule with delay information for case are represented in table 1 and 2 respectively.

Table 1 As-Planned and As-Built Schedule

Activity	Duration	As-planned		As-built	
		Start	Finish	Start	Finish
Owner approved drawings	1	1	1	1	1
Excavate soil	4	1	4	1	4
Install drainage structure	6	3	3	11	16
Backfill	2	9	10	17	18
Owner related delay: Drawing Approval	5	-	-	2	6
Contractor related delay: Equipment unavailability	4	-	-	3	6
Excusable Delay: Rain Delay	5	-	-	6	10

Table 2 Road drainage structure example delays information

Owner responsible delay	The owner fails to approve road drainage structure drawings in time during excavation work and ready the drawings 5 days late.
Contractor responsible delay	The contractor does not have the proper equipment on site required to install the drainage structure on time. An extra 4 days are needed to get equipment.
Excusable Delay	Severe rainfall begins during construction phase. The result is a 5 day rain delay.

4.1. Delay Cause Approach with Time Impact Analysis

In the example below, Delay 1 is the owner's failure to approve the drawings on time (ORD). The schedule is updated to the beginning of the delay, day 1, the delay is spliced into the CPM network, and the adjusted completion duration is determined to be 14 days. These 4 days, the fault of the owner, are awarded as delay damages and time extension. On day 3, the contractor is unable to have the proper equipment on site to install the drainage structure, which shifts the critical path onto this CRD, resulting in an adjusted completion date of day 14. Because the completion date did not change, the contractor is not liable for any delay resulting from this event. Considering weather, Delay 3, further prevents the drainage structure from being installed. Once again, the critical path shifts, this time from the CRD to the ED, extending project completion an additional 4 days to day 18. These 4 days, because they are an excusable delay, are awarded as a time extension. The sum of damages and extensions are 8 days time extension, 4 days delay damages, and 0 days liquidated damages.

Implementing TIA for delay 1, initially, actual status of job is reflected in an updated Schedule of Record. Schedule of Record is updated to beginning of first delay, ORD, which began on day 2. Next step is to insert delay and create Modified Schedule of Record. The observations are as follows. Owner's Liability = Modified Schedule of Record duration (14) – Updated Schedule of Record duration (10) = 14-10 = 4 days time extension. Schedule of Record is updated to beginning of second delay, Contractor Responsible Delay, which began on day 3. So, Contractor's Liability = Modified Schedule of Record duration (14) – Updated Schedule of Record duration (14) = 0 days. Considering excusable delays, Schedule of Record is updated to beginning of third delay, Excusable delays, which

began on day 6. Time Extension = Modified Schedule of Record duration (18) – Updated Schedule of Record duration (14) = 4 days.

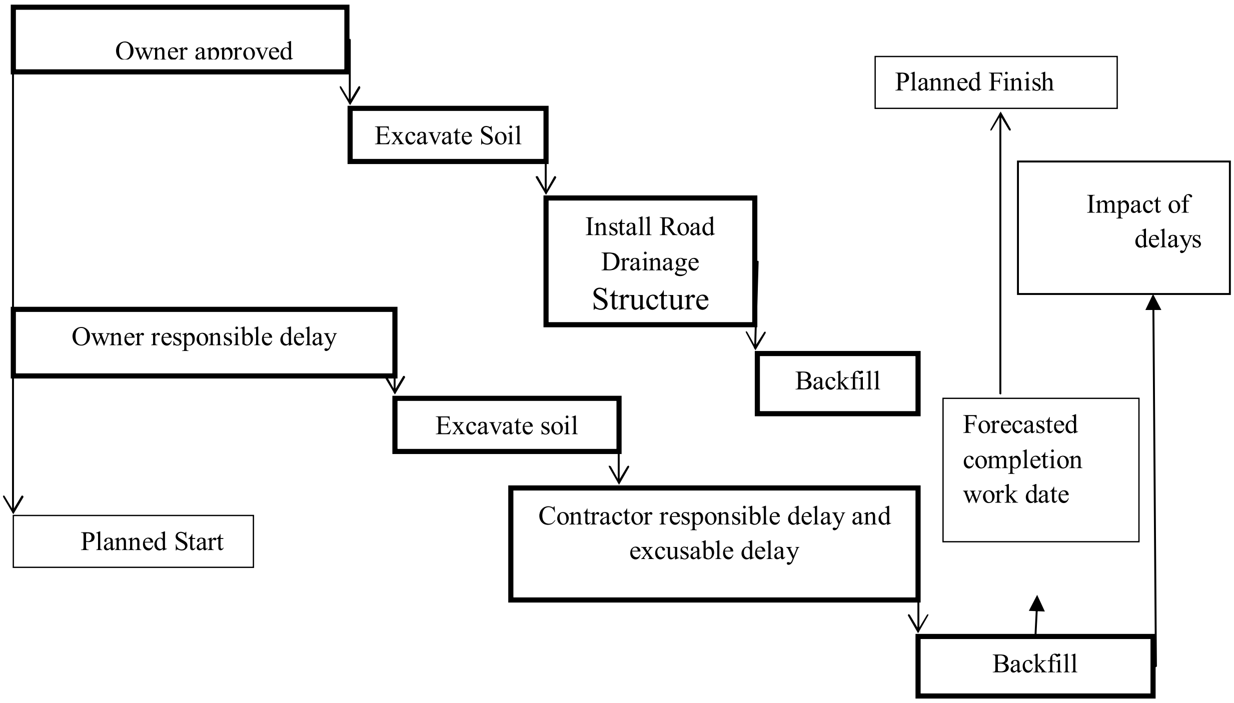

Figure 5 Delay cause approach& delay liability

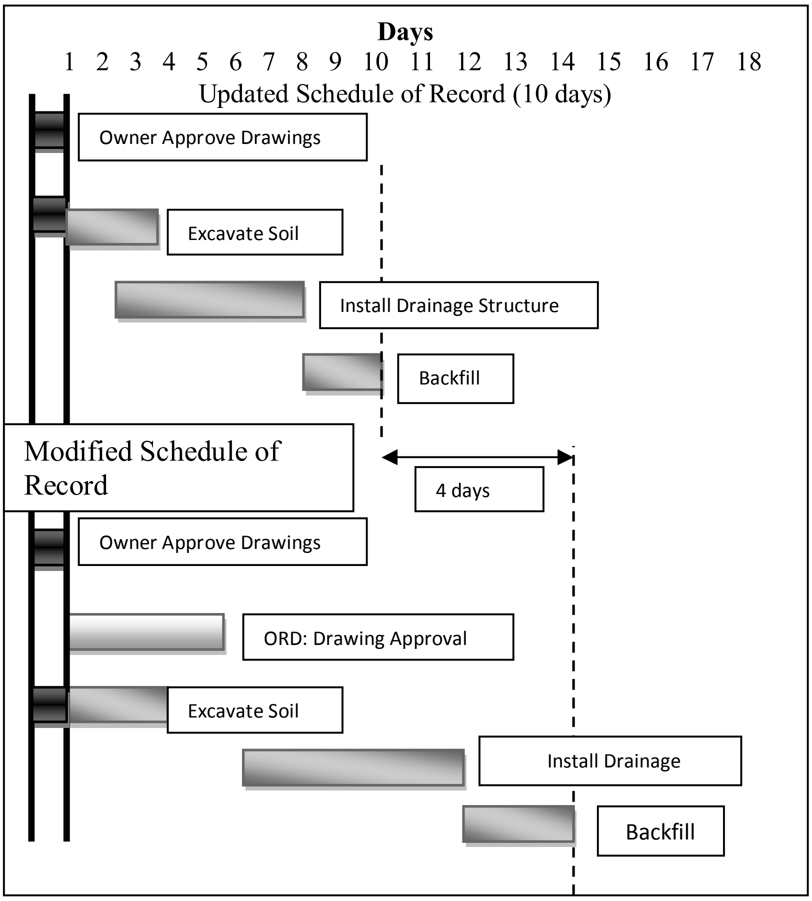

Figure 6 Time impact analysis approach

5. CONCLUSION

In the discussion of the "process" part of the Toyota way model, an endeavour has been made to link a number of Toyota way principles to the as-built schedule as a necessary change for better implementation cum output. It should be noted that the commitment of management, as well as their awareness and understanding, is the most important prerequisite, without which it is not possible to successfully implement this methodology in practice. Performing a detailed time impact analysis on real estate sector construction projects, which are often highly impacted and disrupted, can be challenging. An assessment on the limitations on available project data and information that would support a detailed time impact analysis should be given a high priority before starting a time impact analysis. It is important to note that Toyota way philosophy and process sub-model is more than a set of methods for eliminating waste. In contrast, it can be viewed as a socio-technical system that recognizes the importance of people and the lean construction principles and can aid in achieving total quality management in construction activities by train staff and managing employees to minimize occurrence of delays. Time impact method of delay analysis can be used in delay liability calculation and to solve delay related issues.

REFERENCES

[1] G. Bergantinos, E. Sanchez, "How to distribute costs associated with a delayed project," *Annals of Operations Research*, vol. 109, pp. 159-174, 2002.

[2] G. Stumpf, "Schedule delay analysis," *Cost Engineering Journal*, vol. 42, no. 7, pp. 32-43,2000.

[3] W. Alaghbari, Razali Kadir M. R. A, Salim A, Ernawati, "The significant factors causing delay of building construction projects in Malaysia," *Engineering and Construction Architectural Management*, vol. 14, no.2, pp. 192-206, 2007.

[4] H. Abdul-raman, I. A. Yahya, M.A. Berawi, O. Mohamed and L. W. Wah, "Conceptual delay mitigation model using a project learning approach in practice,"*Construction Management and Economics*, vol. 26, no. 1, pp. 15-27, 2007.

[5] A. A. Aibinu and H.A. Odeyinka, "Construction delays and their causative factors in Nigeria," *Journal of Construction Engineering and Management*, vol. 132, no. 7, pp.667-677, 2005.

[6] A. A. Aibinu and G. O. Jagboro, "The effects of construction delays on project delivery in Nigerian construction industry," *International Journal of Project Management,* vol. 20, pp. 593-599, 2002.

[7] C. Jahren and A. Ashe, "Predictors of cost-overrun rates," J*ournal of Construction Engineering and Management,*vol. 116, no. 3, pp. 548-551, 1990.

[8] D. Arditi and T. Pattanakitchamroon, "Selecting a delay analysis method in resolving construction claims," *International Journal of Project Management,* vol. 24, pp. 145-155, 2006.

[9] M. Mezher and W. Tawil, "Causes of delays in the construction industry in Lebanon," *Engineering Construction and Architectural Management,*vol. 5, no. 3, pp. 254-60, 1998.

[10] B. B. Bramble and M.T. Callahan, *Construction delay claims,* 2nd ed, New York, USA: Wiley, 1992.

[11] A. H. Al-Momani "Construction delay: a quantitative analysis," *International Journal of Project Management,* vol. 18, pp. 51-59, 2000.

[12] M. Majid and R. McCaffer R, "Factors of nonexcusable delays that influence contractor's performance," *Journal of Management in Engineering,*vol. 14, no. 3, pp. 42-49, 1998.

[13] R. L. Peurifoy and W. B. Ledbetter, *Construction Planning and Equipment Methods,*4th ed, New York, USA:McGraw-Hill, 1985.

[14] Jamal M. Assbeihat, Factors Affecting Delays on Private Construction Projects, *International Journal of Civil Engineering and Technology*, 7 (2), 2016, pp. 22-33.

[15] A. M. Odeh and H.T. Battaineh, "Causes of construction delay: traditional contracts," *International Journal of Project Management,* vol. 20, pp. 67-73, 2002.

[16] D. Arditi, G. T. Akan and S. Gurdamer, "Reasons for delays in public projects in Turkey," *Journal of Construction Engineering and Management,*vol. 3,no. 2, pp. 171-181, 1985.

[17] R. Ellis and R. Thomas, *The root causes of delays in highway construction,* NCHRP 20-24, Transportation Research Board, Washington: National Research Council, 2002.

[18] Z. M. Kraeim, "Concurrent delays in construction projects," *Journal of Construction Engineering and Management,* vol. 113, no. 4, pp. 591-601, 1987.

[19] S. A. Assaf and S. Al-Heiji, "Causes of delay in large construction projects," *International Journal of Project Management,* vol. 24, pp. 349-57, 2006.

[20] Lovejoy, "Claims Schedule Development and Analysis: Collapsed As-built Schedule for Beginners." *Cost Engineering Journal,* vol. 46, no. 1, pp. 27-30, 2004.

[21] Paul Louzolo-Kimbembe and Benoîtromaric Mampika-Bathy, Improvement of the Model of Minimization of the Costs in A Time-Overrun Context: Case of Construction Projects, *International Journal of Civil Engineering and Technology*, 5 (9), 2014, pp. 114-134.

[22] Lowsley and Linnett, "About Time: Delay Analysis in Construction." RICS Business Services Limited,2006.